From:
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To: NOAA Postdoctoral Fellowship Review Committee
Subject: Application for a NOAA Postdoctoral Fellowship in Climate and Global Change, 2004
Date: 14th of January, 2004

Dear Committee Members,

I am applying for a NOAA Postdoctoral Fellowship in Climate and Global Change. It was with highest interest that I read your announcement, since the requirements for this fellowship match my experience and interest especially well.

I recently defended my dissertation at the University of Alaska Fairbanks, investigating the impacts of Climate Change on the treeline ecotone in Interior Alaska. I was able to show for the first time that most treeline trees are actually decreasing in growth due to recent warming and that treelines will not necessarily advance if warming continues. I would like to extend this research to investigate the consequences of these findings for carbon dynamics in northern Alaska, especially regional interactions between the terrestrial biosphere and atmosphere using a combination of field based and remote sensing approaches. My fellowship project is titled: **Land-cover change as the driver for carbon budgets at northern treeline in Alaska - From isotopic signature in trees and soils to local and regional feedbacks to the global climate system.**

Rosanne D'Arrigo (Lamont Doherty Earth Observatory, Columbia University), and Jennifer Harden (U.S.G.S, Menlo Park, CA) have enthusiastically agreed to serve as co-hosts for this fellowship, which will enable me to address the coupled interactions between forest growth and soil carbon storage at northern treeline. Based on these interactions, the project will investigate and predict biophysical and biogeochemical feedbacks of Alaska's boreal forest to the climate system. While Rosanne D'Arrigo has worked extensively in the field of paleoreconstruction using tree rings, Jennifer Harden is the lead scientist on the "FOCAL Project", which investigates soil carbon - climate interactions in interior Alaska. Together they provide an ideal team to mentor this interdisciplinary project. The main host institution for this fellowship would be Lamont Doherty Earth Observatory, while Jennifer Harden would mentor the soils part of this project and provide lab space, some travel costs, equipment and materials for soil analysis.

This background has given me a unique perspective, which I feel would be particularly valuable in meeting the opportunities and responsibilities of this fellowship. I am looking forward to hearing from you soon.

Thank you for your time and consideration.

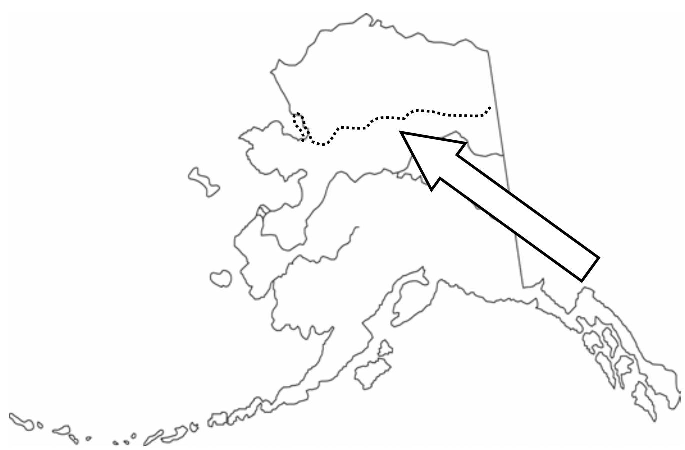
Sincerely,

Martin Wilmking

Proposal to:
2004 NOAA Postdoctoral Program in Climate & Global Change:

Land-cover change as the driver for carbon budgets at northern treeline in Alaska

From isotopic signatures in trees and soils to local and regional vegetation feedbacks to the global climate system



Martin Wilmking, Ph.D.
Currently: Forest Science Department, University of Alaska Fairbanks

Co-hosted by:
Rosanne D'Arrigo, Lamont Doherty Earth Observatory, Columbia University
Jennifer Harden, U.S. Geological Survey, Menlo Park, CA

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Project abstract:

Global Warming strongly affects tundra and boreal forest ecosystems and these ecosystems feed back to climate. Two important feedbacks are: 1) Advance of forest into tundra, which can lead to additional warming through albedo changes and 2) Carbon storage at high latitudes strongly influences atmospheric CO_2 concentrations, but the future of the existing carbon sink there is uncertain. Forest cover and density is an important factor influencing albedo (Feedback 1) and carbon storage (Feedback 2). Here, we propose to study treeline dynamics and above and below-ground carbon storage along three transects of decreasing forest cover across northern treeline in the Brooks Range, Alaska. We will combine five methods to a) identify carbon pools in trees/shrubs/soil at plot level, use b) tree rings, c) stable isotopes and d) historic photographs to estimate recent change in vegetation cover at landscape level, and ultimately scale our results up to regional level using IKONOS/Quickbird imagery (e). This unique and powerful approach promises spatially explicit results of present and future treeline dynamics and carbon storage in northern Alaska.

CV - Postdoctoral Fellow: Martin Wilmking, Ph.D.

Educational background:

2003	Ph.D. (interdisc.) Landscape Ecology and Earth System Science at University of Alaska Fairbanks (UAF), overall GPA 4.0
2002 (spring)	Advancement to Candidacy in Ph.D. Program, UAF
1999 (fall)	Begin of Ph.D.-Project at UAF Advisor: Glenn P. Juday, Forest Science Department
1998 (fall)	Diplom (Masters)-Thesis in Geoecology with Prof. H. Barsch, Universitaet Potsdam, Potsdam, Germany, graduated with "highest honors" (mit Auszeichnung, Grade: 1.1, grades can range from 1 to 6, 5 and 6 are failed, “mit Auszeichnung” is awarded for a grade point average of 4.0)
1997 (summer)	Research with Larry Hinzman, UAF: Development of a Hierarchical Classification Scheme for Arctic Ecosystems in the Kuparuk River Basin
1996 - 97	Ambassadorial Rotary Scholar, UAF
1995	Vordiplom (comprehensive exams for Diplom thesis), grade: A
1993	Begin studies at Universität Potsdam, major: Geoecology
1982 - 91	Evangelisch-Stiftisches-Gymnasium Gütersloh, Germany (high school diploma)

Honors and Awards:

2003	Thesis completion fellowship, University of Alaska Fairbanks (US$ 7,600)
2003	Travel grant, University of Alaska Fairbanks (US$ 600)
2002	Researcher in Residence at the Denali Foundation, Denali National Park, Alaska
2001	Grant from the Center for Global Change and Arctic System Research (US$ 8,579)
2000 - 2003	Canon National Park Science Scholar (US$ 75,000)
2000	Grant from "The Exploration Fund" (US$ 1,200)
1999 - 2002	Full Scholarship (HSP III) from the German Academic Exchange Service (DAAD) for Doctorate Studies at UAF (US$ 45,000)
1999	NASA-MSU Professional Enhancement Award
1997 to present	Member (Student International) of "The Explorers Club"
1996	Rotary International special appointment: Scholar of the program: "Preserve Planet Earth"
1996 - 1997	Ambassadorial Scholar, Rotary International (US$ 25,000)
1995 - 1998	Scholar of the "German National Scholarship Foundation" (top 0.8% of all students in Germany)

Scientific Field Experience:

2000 - 2003	Extensive field-work in remote regions of northern and central Alaska: Dendrochronology, landscape ecology, microclimatology.
1997	Member of the German - Mongolian Expedition "Uvs-Nuur", Mongolia: Landscape ecology, soil surveying, meso-scale climatology.
1996	Member of the "Taymyr-Severnaya Zemlya Expedition 1996", northern Siberia, Russia: Lake sediment coring.

Publications and Abstracts (selected):

Wilmking M., in prep. The moisture stress hypothesis - Changing control parameter in Alaska's boreal forest. For *Oiko*s.

Wilmking M., Juday G.P., Barber V.A. and Zald H.S.J. (in review) Recent climate warming forces contrasting growth responses of white spruce at treeline in Alaska through temperature thresholds. *Global Change Biology.*

Wilmking M., Juday G.P., Ibendorf J., Terwilliger M. and Barber V.A.(in review) Modeling spatial variability of treeline white spruce growth responses to Climate Change - Outlook for two National Parks in Alaska. *Landscape and Urban Planning.*

Barber V.A., Juday G.P., Finney B.P. and **Wilmking, M.,** (in press). Reconstruction of summer temperatures in Interior Alaska from tree ring proxies: Evidence for changing synoptic climate regimes. *Climatic Change.*

Wilmking M., Krüger W. (in press) Development of landscape ecology in Europe and North America, in Steinhardt U., Blumenstein O., Barsch H. (Eds.) Landschaftsökologie - Theorie. Methodik, Anwendung. Heidelberg-Berlin.

Wilmking M. and Ibendorf J. (in press). An Early Treeline Experiment by a Wilderness Advocate - Bob Marshall's Legacy in the Brooks Range, Alaska. *Arctic.*

Wilmking M., 2003. Are Alaska's northernmost trees doing better or doing worse? - Past and future global warming effects on growth and carbon uptake in white spruce - (Abstract) 1st International Young Scientist's Conference on Global Change, Trieste, Italy.

Juday G.P., Barber V., Rupp S., Zasada J., and **Wilmking M.,** 2003. A 200-year perspective of climate variability and the response of white spruce in Interior Alaska. Chapter 13 In: Greenland, D., Goodin, D., and Smith, R. (editors). Climate Variability and Ecosystem Response at Long-Term Ecological Research (LTER) Sites. Oxford University Press.

Wilmking M., Juday G.P., Ibendorf J. and Terwilliger M., 2003. “Winners and Losers” - Climate forcing on tree growth-landscape relationships in Alaska. - Park planning for the 21st century - (Abstract) 6th World Congress of the International Association for Landscape Ecology (IALE), Darwin, Australia.

Barber V.A., Juday G.P., Berg E., and **Wilmking M.,** 2002. Assessment of Recent and Possible Future Forest Responses To Climate in Boreal Alaska (extended abstract) in Kankaanpaeae S., Mueller-Wille L., Susiluoto P., and Sutinen M.L. (Eds). *Northern Timberline Forests: Environmental and Socio-economic Issues and Concerns. The Finnish Forest Research Institute Research Papers* 862.

Wilmking M. and Beierkuhnlein K., 2002. Landscape boundaries, Ecotones, chapter 2.5. in O. Bastian, U. Steinhardt (eds.). Development and Perspectives in Landscape Ecology - conceptions, methods, application -. Kluwer.

Wilmking M., 2001. Trees on the move? Global Climate Change and Treeline Movement in Denali National Park. *The Denali Foundation Newsletter* Vol. 2/1.

Wilmking M., 1999. A Theoretical Approach to Landscape Classification: Benefits and Drawbacks of a Hierarchical Framework Applied to a Transect in the Biosphere Reserve Uvs-Nuur, Mongolia, (Abstract) 5th World Congress of the International Association for Landscape Ecology (IALE), Snowmass, Village, Coloraldo.

Melles M., Bolshiyanov D.Y., Samarkin V., Müller-Lupp T., **Wilmking M.,** 1997 Lake sediment coring on the Severnaya Zemlya Archipelago, Central Siberia, in 1996 - a preliminary report. - In: S. Horie (Ed.) IPPCCE Newsletter 10:106-112.

Referees:

Prof. Glenn P. Juday (Thesis advisor): Forest Science Dep., University of Alaska Fairbanks, Fairbanks, AK 99775, U.S.A.,
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Title of Dissertation (Ph.D. awarded December 2003):

"The Treeline Ecotone in Interior Alaska - From theoretical concept to planning application and the science in between".

Abstract:

Treelines have been the focus of intense research for nearly a hundred years, in part because they represent one of the most visible boundaries between two ecological systems. In recent years however, treelines have been studied, because changes in forest ecosystems due to global change, e.g. treeline movement, are expected to manifest first in these areas.

This dissertation focuses on the elevational and latitudinal treelines bordering the boreal forest of interior Alaska. After development of a conceptional model of ecotones as three-dimensional spaces between ecosystems, I offer a historical perspective on treeline research and its broader impact in the Brooks Range, Alaska.

Dendrochronological analysis of >1500 white spruce at 13 treeline sites in Alaska revealed both positive and negative growth responses to climate warming, challenging the widespread assumption that northern treeline trees grow better with warming climate. Hot Julys (over ~12ºC at the site) decreased growth of ~40% of white spruce at treeline in Alaska, whereas warm springs enhanced growth of others. These temperature thresholds control increases and decreases in growth rates and have occurred more frequently in the late 20th century due to a warming climate.

Based on the relationships between tree-growth and climate as well key landscape characteristics, we modeled future tree-growth and distribution in two National Parks in Alaska and extrapolated the results into the 21st century using data from five General Circulation Models. In Gates of the Arctic National Park, our results forecast enhanced growth at low elevation, whereas other areas will see changes in forest structure (dieback of tree-islands, infilling of existing stands). In Denali National Park, our results indicate possible dieback of white spruce at low elevations and treeline advance and infilling at high elevations. This will affect the road corridor with a forest increase of about 50% along the road, which will decrease the possibility for wildlife viewing. Surprisingly, aspect did not affect tree growth - climate relationships.

Without accounting for opposite growth responses under warming conditions (i.e. some tree population decrease growth, some enhance growth), temperature thresholds, as well as meso-scale changes in forest distribution, climate reconstructions based on ring-width will miscalibrate past climate, and biogeochemical and dynamic vegetation models will overestimate carbon uptake and treeline advance under future warming scenarios.

Project description: "Land-cover change as the driver for carbon budgets at northern treeline in Alaska - From isotopic signature in trees and soils to local and regional feedbacks to the global climate system":

Introduction - Global Warming and high latitude ecosystems:

Global Warming strongly affects arctic and subarctic ecosystems (Serreze et al., 2000), causing earlier breakup of rivers (Sagarin and Micheli, 2001), longer growing seasons (Keeling et al., 1996), degradation of permafrost (Osterkamp and Romanovsky, 1999), and expansion of trees into tundra (Suarez et al., 1999; Lloyd et al., 2002). Changes are most profound on ecosystem boundaries, making the border between boreal forest and arctic tundra, the northern treeline, important for ecological monitoring (Hansen and di Castri, 1992). Chapin et al. (1995) showed that vegetation zones eventually shift in adaptation to a warmer climate. But not only is the distribution of northern vegetation zones controlled by climate, the biomes themselves feed back to climate. Feedback can be **biophysical** and **biogeochemical**:

1) One of the major **biophysical** feedbacks is the position of the northern treeline. A northward expansion of boreal forest due to global warming could lead to further warming of up to 4°C in spring and 1°C in other seasons (Foley et al., 1994), because boreal forest has lower albedo than tundra (Chapin et al., 2000).

→ **A northward advance of forest (land cover change) into tundra under warming conditions therefore will enhance warming even further.**

2) One of the major **biogeochemical** feedbacks is storage and release of carbon. High latitude forests contain 49% of all carbon stored in forested ecosystems (Dixon et al., 1994), nearly 40% of all terrestrial soil carbon (more than any other terrestrial biome; McGuire and Hobbie, 1997) and are especially important for such feedbacks (Chapin and Matthews, 1993). A large carbon sink is reported in temperate and boreal forests today (Fan et al., 1998; Liski et al., in press), but the future of this sink is uncertain. Tundra areas can act as sinks or sources of CO_2 (Oechel et al., 1993, 2000). Therefore, forest expansion into tundra would reduce warming by decreasing atmospheric CO_2 concentration through increased growth and storage. However, warmer temperatures also enhance plant and soil respiration (increased CO_2 flux into the atmosphere), permafrost thaw and may release frozen carbon pools to the atmosphere.

→ **The cumulative effect of warming on carbon storage or release, the change in "net ecosystem production" (NEP) of boreal forest and arctic tundra, is poorly understood.** NEP is defined here as the net carbon accumulation by ecosystems (Randerson et al., 2002).

We propose to study treeline dynamics (biophysical feedback) and carbon budgets (biogeochemical feedback) at the northern treeline in Alaska.

Background - Alaska as a player:

Alaska contains all true boreal forest and arctic tundra in the U.S. The northern treeline dividing Interior Alaska's boreal forest from arctic tundra runs east-west in the southern foothills of the Brooks Range. The Brooks Range, a topographic barrier for treeline advance (Rupp et al., 2001), stretches nearly 1000km from the Beaufort Sea to the Canadian border. Kobuk Valley National Park (KOB), Gates of the Arctic

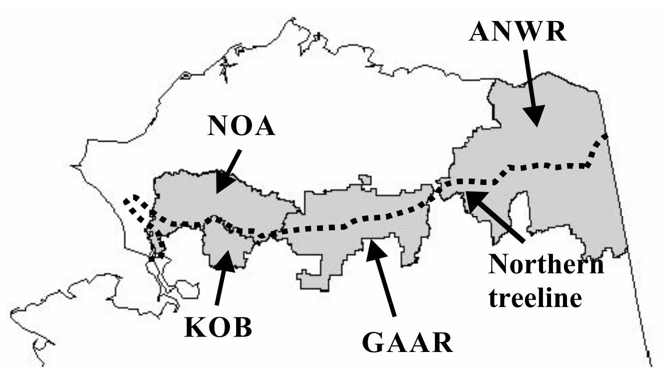

Figure 1: Northern treeline in Alaska on the southern side of the Brook Range runs through four nationally protected units.

National Park and Preserve (GAAR), the Noatak National Preserve (NOA) and the Arctic National Wildlife Refuge (ANWR) make this the largest stretch of protected area in the United States (Fig. 1), providing outstanding opportunities to study the effects of global change on natural ecosystems relatively undisturbed by man.

In the last decades mean annual temperatures in interior Alaska have increased (Fig. 2), and the latest climate regime (coupled to the Pacific Decadal Oscillation) is the hottest and driest of the last century (Barber et al., in press). Evidence suggests that the most productive upland forest sites in interior Alaska (Barber et al., 2000) and at treelines (Jacoby and D'Arrigo, 1995) are limited by moisture rather than temperature and that further warming will actually decrease growth of most of these trees. Wilmking et al. (submitted A) identified three growth responses in white spruce at treeline in response to warming: 1) negative 2) positive or 3) not significant. These responses have intensified in the last 50 years and are controlled by temperature thresholds, which will be exceeded more often if warming continues. Since about 40% of all trees at treeline show detrimental growth with warming (Wilmking et al., submitted A), a simple shift of forest into tundra does not seem very likely. Instead, the spatial distribution of different growth responses is controlled by stand density (Wilmking et al., submitted B) and trees usually advance on moderately to well drained soils (Lloyd et al., 2002). In addition, disturbance agents, such as fire (Kasischke and Stocks, 2000) or insects (Hard, 1985) may exert control over treeline areas. Overall, the sensitivity of the treeline ecotone to future warming will vary across space and time (Lloyd et al., 2002). Possible ecosystem trajectories include:

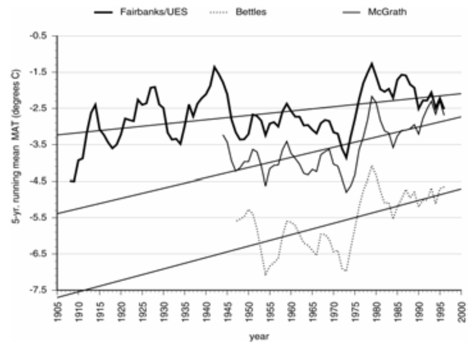

Figure 2: Mean annual temperatures (MAT, 5 years smooth) at three locations in interior Alaska.

1) Infilling of existing stands (e.g. Stottlemeyer et al., 2000).
2) Advance of trees into tundra (e.g. facilitated by thermokarst activity, Lloyd et al., 2002).
3) Structural changes within treeline forests. Decreasing tree density in some parts due to stress-related mortality. Infilling in formerly marginal areas (Wilmking et al., submitted B).

Warming will not only trigger treeline movement (albedo change), but also changes in the carbon budget in boreal forest and arctic tundra. Alaska will be a major player in all carbon budget calculations in the U.S., because of 1) massive amounts of carbon stored, 2) the present carbon sink in the conterminous U.S. is projected to significantly decrease during the 21st century (Hurtt et al., 2002), giving Alaska an even larger role in the overall U.S. calculation. Warming, however, can decrease C-storage (net CO_2 flux into the atmosphere **(↑)** = positive feedback to warming), or enhance it (net CO_2 flux out of the atmosphere **(↓)** = negative feedback). At the northern treeline, several ecosystem trajectories are feasible under warming conditions:

1) A tundra area stays tundra. Possible changes: Increase in shrubs (Sturm et al., 2001) **(↓)**, soil drainage, decrease of long term C-storage in soils (Harden et al., 1997; 2000) **(↑)**.
2) A forest stays a forest: Stand density increases, more C stored in woody biomass **(↓)**, but also more competition and less growth (Wilmking et al., submitted B) **(↑)**.
3) Tundra changes to forest: Higher biomass above-ground **(↓)**, warmer soils, more decomposition (Kane et al., 2003) **(↑)**.

All of these factors and their spatial extent are interconnected and not well understood at the landscape scale, despite studies on several aspects of this puzzle (e.g. Trumbore and Harden, 1997; Harden et al., 1997; Oechel et al., 1993 and 2000; Stottlemeyer et al., 2000; Lloyd et al., 2002 and 2003). The challenge is the extrapolation of plot-based results into space. Linear plot-based extrapolations from existing results will not be able to capture regional gradients (e.g. effect of the precipitation gradient) or nonlinear behavior (e.g. threshold effects) in the immense region of northern Alaska. On the other hand, large-scale modeling studies often lack real ground based validation.

What is needed is a hierarchical approach that measures variability on a plot level, validity tests at the landscape level and extrapolation of information from plot and landscape to regional and global scales.

We propose to use a nested hierarchy of investigation to integrate site-specific studies into a regional framework. We will study the impact of increasing forest cover at northern treeline in Alaska on above and below-ground carbon storage and the effects of a warming climate on these ecosystem processes around the following **six hypotheses**:

1) The relationship between above and below-ground carbon is controlled by vegetation, therefore vegetation shifts will result in transient loss or gain of belowground carbon.
2) Stand density and drainage regime control growth responses of white and black spruce.
3) Carbon storage differs significantly in forests of varying tree density under warming climate.
4) Drought stress in spruce is a regional signal at northern treeline.
5) Tree and shrub density changed significantly on a landscape level in the last 50 years.
6) Extrapolation of plot-based results is possible using the relationship of tree density and carbon storage regime.

Methods:

We propose to combine five methods (Fig. 3) to: Identify above and below-ground carbon pools along three transects across northern treeline (Method A), estimate historic rates of carbon uptake above (Method B) and below-ground (Method C), identify historic changes in vegetation distribution at all sites by reconstruction (Method B) and at two sites by photo-interpretation (Method D), and scale our ground based results up to a regional level (Method E). **All methods produce area-weighted results to allow for spatially explicit extrapolation!**

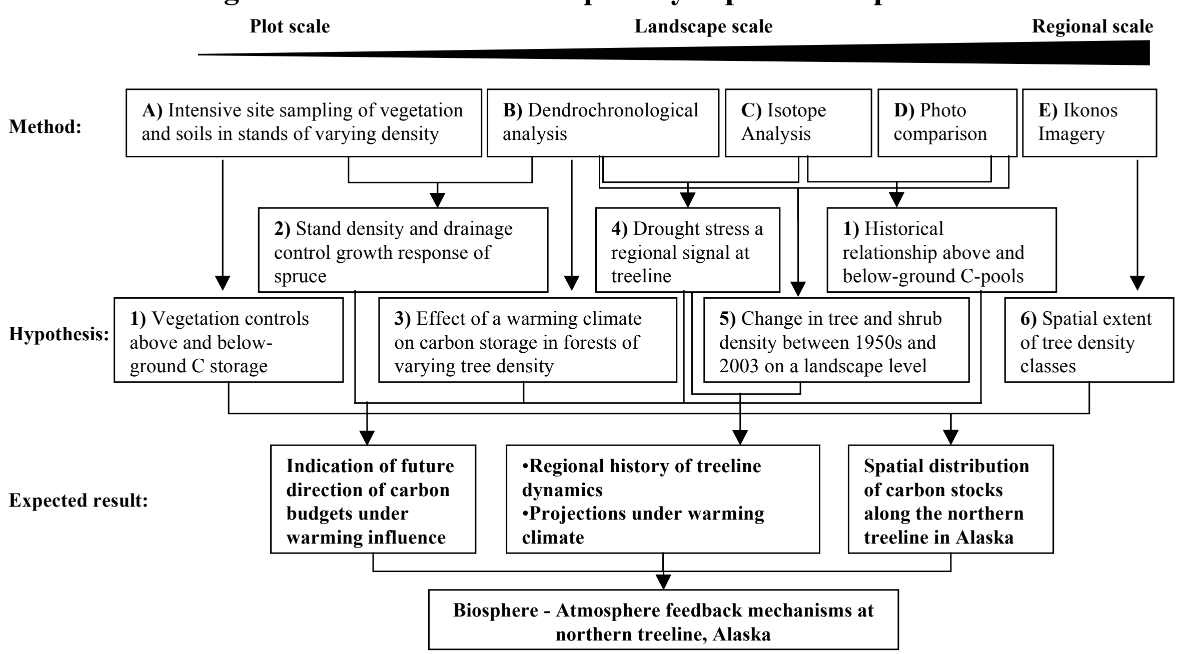

Figure 3: Five methods of increasing scale (A-E) will be combined to test six hypothesis (1-6). This combination promises a powerful approach to characterize the feedbacks between biosphere and atmosphere at northern treeline in Alaska at plot to regional scale.

A) Intensive site sampling. Anticipated result: Carbon pools under varying forest density and two drainage regimes.

We will sample along three transects (representing regional precipitation regimes), one in each of the three subsections of the Brooks Range (Fig. 1): Western (KOB and NOA), Central (GAAR) and Eastern Brooks Range (ANWR). Each transect will be located along a major river valley with a low pass to the North Slope (possible corridor for treeline advance). It will consist of five sites with consecutively decreasing forest cover: Closed canopy forest (100% cover), open spruce forest (75%), transition zone (50%), scattered trees (25%) and tundra (0%). Each site will cover two drainage regimes, well drained and wet. In each drainage regimes a plot of 20x20m will be marked. Within each plot we will sample three "layers", trees, shrub/grass and soil. We will collect penetrating tree cores from each white or black spruce with a diameter at breast height (dbh) of >2.5cm, smaller trees will be aged using yearly node counts. Dbh and height for each tree will be used to calculate biomass using allometric functions. We will record brush cover, distribution and height and sub-sample two 1x1m areas (shrubs) and 0.2x0.2m (moss, lichen) per plot destructively to estimate aboveground biomass. We will collect 10 evenly spaced soil cores per plot (0-100cm, 30cm in permafrost or rocky soil) and describe soil profiles in two soil pits (Fig. 4). Before coring the mineral soil, we will sample 10x10cm of the organic mat to determine carbon content. We will record position of each tree, vegetation samples, soil core and pit and survey the plot to control for microtopography.

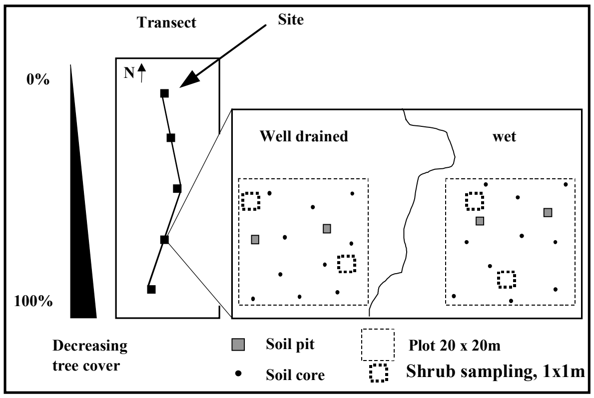

Fig.4 : Idealized sampling protocol in two adjacent plots under two drainage regimes (wet or well drained). Pairs of plots (sites) are arranged along a transect starting in closed canopy forest (100% tree cover) and progressing into arctic tundra (0% tree cover).

Laboratory analysis: Samples of vegetation and organic mat will be dried, weighted and carbon content calculated (Hakkila, 1989). Soil analysis follows accepted standards (Boone et al., 1999) and includes: C/N ratio, Phosphor content, bulk density.

B) Dendrochronological analysis. Anticipated result: History of aboveground carbon uptake and its relationship to climate in forests of varying tree density. Relationship of tree age with distance to treeline.

Tree cores will be measured in the tree ring laboratory at LDEO according to accepted standards (Stokes and Smiley, 1968; see letter from co-host at LDEO). We will transform annual width increment into area adjusted basal area index and correlate annual growth of individual trees and stands with climate parameters from stations nearby (Kotzebue, Bettles, Fort Yukon and Fairbanks).

C) Carbon isotope analysis: Anticipated result: Verify regional drought stress signal in trees. Below-ground carbon accumulation.

C^{13} analysis in tree cores will be used to test for drought stress (Barber et al., 2000), which we expect to increase with distance to Alaska's west coast (declining precipitation) and drainage. Samples from our three transects will provide a regional data set to test this hypothesis.

In sphagnum sites (wet) where organic matter accumulates with little mixing we will use C^{14} dating of soil samples in different depths to calculate the rate of organic accumulation (if any) since the "bomb-spike" in the 1950-60s (Trumbore and Harden, 1997). Those measurements will give us the amount of new carbon each site has accumulated, however, those amounts could have been offset by the release of older and deeper carbon. Since there is no direct way of addressing changes in old carbon stocks, we propose the following approaches: 1) Our study will provide an ecosystem snapshot in time, which can be compared to future carbon measurements (Arctic Network Inventory and Monitoring Program, NPS), 2) We will use unchanged forest cover as control sites for detecting changes in carbon pools where forest cover has shifted. E.g. site A is a tundra site storing x kg Carbon/ha, site B has 25% forest cover and stores y kg Carbon/ha. If site A is converted to a forest with 25% cover, the amount of carbon stored or released will be the difference between x and y. At a smaller scale, we will identify recent disturbances (e.g. thermokarst) at some of our sites and collect soil samples at increasing distance to the disturbance location. Assuming homogeneous substrate we can compare carbon content of soils in "strongly affected sites" (close to the disturbance) to "less affected sites" (those further away), thus again base predictions of future release or storage potential on the differences in the amount of carbon stored at these sites today.

D) Photo-comparison (1940s - 2003). Anticipated result: Change in shrub-layer and tree distribution in the last 50 years (Cooperation with M. Sturm, CRREL).

Around 1940, low elevation air-photo transects were flown across northern Alaska and were rephotographed in 2003 by the Cold Regions Research and Engineering Laboratory (supervision, M. Sturm). Two of the flight lines cover the forest-tundra ecotone and provide a unique opportunity to study changes in tree and shrub density and establishment (Sturm et al., 2001). Dr. Sturm has asked for our cooperation and we propose to locate two of our transects (Kugururok in NOA, John River in GAAR) along the flight lines to use the additional information provided in the historical photographs to investigate changes in treeline position and tree and shrub-density. Combined with Method C, we will have two ecosystem time-slices, one around 1950 (photo for aboveground ecosystem properties, and bomb-spike for below-ground) and the other from 2003/4 with our field effort. This will be an unparalleled data set in these latitudes.

E) Remote Sensing (IKONOS/Quickbird). Anticipated result: Upscaling of C-budgets (Method A), growth and accumulation history (Method B,C,D) using forest cover classes as tool to translate site information into space → **Map: Above and belowground carbon pools in kg/ha.**

We will explore the use of high-resolution imagery to scale our plot and transect-based results up to the regional level. Sites with differing tree density create different specific spectral signatures (Vierling et al., 2002). Plot-based information (such as carbon storage regime) will always be tied to a specific tree density class in our study. We use these tree density classes to extrapolate plot-based results into a larger area.

Timetable:

Year 1 (2004)	Spring	Application for collecting permits (NPS), hiring of students and field assistants, preparations for field-work, purchase of field supplies.
	Summer	Field work, Western Transect in KOB and NOA and Central transect in GAAR. Tree coring, soil and vegetation sampling.
	Winter	Laboratory analysis of tree cores and soil samples from Year 1. Begin spectral analysis of IKONOS/Quickbird Imagery, begin isotope analysis of tree cores.
Year 2 (2005)	Spring	Continue spectral analysis of IKONOS/Quickbird Imagery. Isotope analysis of soil samples. Preparations for field-work. Fellow attends Scientific Meeting.
	Summer	Field work, eastern transect (ANWR). Tree coring, soil and vegetation sampling. Finish spectral analysis of IKONOS/Quickbird Imagery.
	Winter	Laboratory analysis of tree cores and soil and vegetation samples from Year 2. Statistical analysis of samples. Writing of professional papers - Synthesis - Fellow attends Scientific Meeting.

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Budget:

A. Salaries and wages	Year 1 (2004)	Year 2 (2005)	Requested from NOAA
Postdoctoral Researcher (PI)	Provided by NOAA Postdoc. Fellowship		**Fellowship requested**
Field assistant (Student)	Travel costs supported by US DOE and German Academic Exchange Service		**0**
B. Travel			
Scientific meetings	provided by Lamont Doherty Earth Observatory (LDEO)		**0**
Travel to USGS soils lab	provided by USGS in year 1 and 2		**0**
Road travel (0.365$/mile)		219	**219**
Charter flights (fixed wing)	1540	1925	**3465**
C. Equipment			**0**
D. Supplies and services			
Isotope analysis	provided by (LDEO)		**0**
Field supplies	provided by LDEO and USGS		**0**
Laboratory Supplies	provided by LDEO and USGS		**0**
IKONOS/Quickbird imagery	provided by NPS and US DEO		**0**
Total Year	**1540**	**2144**	**Fellowship + 3684**

Budget Justification:

Personnel:

Postdoctoral Fellow: Covered by NOAA Postdoctoral Fellowship.

Student hire: One student will help the PI in the field and lab for 3-4 months per year, covered by US DOE and German Academic Exchange Service.

Cooperation with Universities of Eberswalde and Potsdam, Germany: In the last years, the PI has collaborated with the University of Potsdam, Germany, providing mentoring and logistical support to two students pursuing Master's degrees in Germany. As exchange for this support, both students helped the PI in the field and lab at no cost to the PI. We plan to extend this collaboration (partly supported by the German Academic Exchange Service, transportation cost), to give one student per year the opportunity to gain experience and work closely with the PI and co-hosts, **see also letter of support, Prof. Steinhardt, Eberswalde, Germany.**

Travel:

Plane flights: Nearly all of the Brooks Range is only accessible by air. We will be traveling to the western and eastern transects from Fairbanks by charter plane. Charter is $385/hour for a Chessna 185 on floats. We will use the road to access the other transect (Central transect). For transportation from site to site along each transect, we will hike and use canoe and raft to comply with park service regulations. Year 1: One transects * 4 hours * $385 = $1540. Year 2: One transects * 5 hours * $385 = $1925. The National Park Service has offered help in air transportation and we expect to offset at least half of our air charter as in-kind support. In that event we will allocate the additional funds to increase sampling depth of isotope analysis. **All travel to field sites will be covered by the $2000/year travel allowance provided by NOAA**.

Road travel: In Year 1 we will drive to one the central transect (GAAR) by private vehicle ($0.365/mile). **All travel to field sites will be covered by the $2000/year travel allowance provided by NOAA**.

Scientific meetings: In Year 1 and 2, the Postdoctoral Fellow will report to the scientific community about the progress in this project. Travel support, meeting costs etc. will be provided by the host (LDEO).

Equipment:
No equipment needs to be purchased

Supplies and Services:
Isotope analysis: C^{13} analysis of samples for drought stress model: 30 annual rings (pooled from 4 radii each from 4 trees) * 6 transects * 4 density types, support provided by LDEO
C^{14} analysis of soil samples will be done in cooperation with Ted Schuur, FIU. All travel funds offset by in-kind support from the Park Service will also be allocated to C^{14} analysis.
Field supplies: All field supplies will be provided by the co-hosts at LDEO and USGS.
Laboratory supplies: All laboratory supplies will be provided by the co-hosts at LDEO and USGS.
IKONOS/Quickbird imagery: In order to upscale from our density controlled plots, we will purchase IKONOS or Quickbird scenes for each transect ($60/km^2). IKONOS imagery for parts of GAAR and WEAR will be provided free of charge from the National Park Service, US DOE will provide additional funds ($5600).

Other support:

Pending:
NSF, Office of Polar Programs, "Integration of top-down and bottom-up approaches for determining regional scale moisture stress in boreal forests experiencing climate warming - spatial and temporal comparisons" (submission January 2004)
Role: Wilmking, co-PI (Amount requested US$ 35,340),
Total amount requested: US$ 1,200,000 for 5 years
NOAA, "Causes in variability of carbon uptake in Alaska boreal forest: Transect, isotopic, and greenhouse studies" (submitted June, 2003)
Role: Wilmking, co-PI (Amount requested US$ 44,817)
Total amount requested: US$ 277,996 for 2 years

Available:
US DOE, NIGEC/WESTGEC (subcontract through Columbia University), "Response of Pacific Northwest and Alaskan Forests to Recent Multiple Environmental Changes"
Role: Barber, Juday, contractors, Total amount US$142,000 (7/1/02 - 6/31/05)
Val Barber, Glenn P. Juday have expressed support for this project **(see attached letter)**.
IKONOS imagery ($5600) and travel costs of two students (2 * $3000) will be covered.
NPS, The National Park Service (Gates of the Arctic and Western Arctic Parklands) have expressed support for the project **(see attached letters)**. They will provide space on park aircraft (subject to availability), equipment storage, crew housing and logistical support. We plan to coordinate our field effort with the Arctic Network, a new initiative for long-term monitoring of natural resources in northern Alaska. Also, the Park Service will provide IKONOS imagery for most field sites and for upscaling of results to the regional level.
University of Applied Sciences, Eberswalde, Germany, Prof. Steinhardt has expressed support for the project **(see attached letter)** and will coordinate travel of one to 2 students per year to Alaska to help the PI in the field and lab. Mentoring of these students will be provided by the PI and co-hosts during their stay in Alaska and at the co-hosting institutions.

Statement of relevance:

The proposed work links several specific research foci as identified in the fellowship announcement. The boreal forest is a major player in the global carbon calculations, but the direction of future ecosystem carbon dynamics is unclear under warming climate.

- We will analyze the regional impact of the Pacific Decadal Oscillation (PDO) on growth performance of white and black spruce, especially the impact of the recent dry and hot climate regime at northern treeline in Alaska.
- The northern treeline is a globally important ecosystem boundary, its fluctuations in space due to climatic changes feedback to climate through coupled processes of atmosphere and biosphere (treeline advance - decrease in albedo - increase in warming; treeline advance - increased carbon sink - decrease in warming).
- CO_2 is one of the most important trace gases. The future of the high latitude carbon sink is uncertain, especially if climate warming forces new ecosystem trajectories. We will address short and mid term variability in ecosystem carbon stocks and predict future carbon uptake potential under warming conditions.
- Using tree rings we will document and analyze past climate-vegetation interactions, resulting in a high-resolution history of growth and carbon uptake in northern Alaska.
- Using isotopic methods we will verify drought stress as a recent regional signal at northern treeline and calculate rate of carbon accumulation in high latitude soils.
- We will analyze the impact of hydrometeorological processes, in particular rain, soil moisture and permafrost on the vegetation and the capacity of the vegetation to sequester carbon under changing environmental conditions.
- Using newly available high resolution imagery, we will scale results from plot level work to regional scales resulting in high resolution maps of future carbon uptake or release potential under warming conditions in northern Alaska.

In summary, this project links nearly all research foci identified in the fellowship announcement under one of the pressing questions in climate change studies today:

"What will happen to the high latitude carbon sink?"

Eligibility to work in the U.S.:

The PI is a German Citizen, who has been pursuing his Ph.D. in the U.S. in the last four years. He graduated 12/2003 and is therefore eligible for Optional Practical Training and a temporary work permit. In addition, however, he has been processing paperwork with the INS to obtain **permanent resident status** under the Diversity lottery case number: **2004-SA00001438** and will receive resident status in 4/2004.

United States Department of the Interior
National Park Service
Western Arctic National Parklands
PO Box 1029, Kotzebue, Alaska 99752
Phone: (907) 442-3890
Fax: (907) 442-8316

January 12, 2004

Martin Wilmking
360 O-Neill Building
Forest Science Department
University of Alaska Fairbanks
Fairbanks, Alaska 99709

Dear Martin,

Thank you for your recent communication with the Resource Management staff at Western Arctic National Parklands (WEAR). The proposal to the NOAA Postdoctoral Fellowship Program entitled "Land-cover change as the driver for carbon budgets at northern treeline in Alaska – From isotopic signature in trees and soils to local and regional feedbacks to the global climate system," is of great interest to us! We recognize that the landscapes we manage are very dynamic and susceptible to rapid ecological responses brought about by climate change. Your proposed work would be most helpful to us as we work to better understand the tundra/forest ecotone that exists throughout our Park units.

The staff at WEAR will gladly assist you in any way possible to obtain the necessary research permits for your proposed project. In addition, we could provide logistical support such as crew housing (on a space-available basis) and equipment storage. We may also be able to help you with float or wheel plane transportation. While we cannot guarantee space on any specific flights at this time, we will strive to include you in our aviation plans. To ensure the success of your project and to facilitate the potentially complex logistics that are involved with Arctic projects, I ask that you work closely with our Chief of Resources, Tom Heinlein. Please contact Tom at 907-442-8303 if you have any further questions.

We wish you the best of luck with your funding pursuits and look forward to working with you in the future.

Sincerely,

Julie Hopkins
Superintendent

United States Department of the Interior

National Park Service
Yukon-Charley Rivers National Preserve
Gates of the Arctic National Park and Preserve
201 First Avenue
Fairbanks, Alaska 99701

January 13, 2004

Martin Wilmking, Ph.D.
360 O'Neill Building
Forest Science Department
University of Alaska Fairbanks 99709

Dear Martin,

Thank you for stopping by and meeting with my Resource Chief Tom Liebscher and myself to describe your new project and funding pursuits. The proposal to the 2004 NOAA Postdoctoral Program in Climate and Global Change entitled "Land-cover change as the driver for carbon budgets at northern treeline in Alaska – From isotopic signature in trees and soils to local and regional feedbacks to the global climate system", sounds quite exciting. Nationally, the interest in carbon sequestration and its relevance to resource management across several disciplines is being recognized. We in the northern latitudes are particularly interested in the long-term ecological effects of any global warming, and the visible demonstration of those effects. Your project proposal would help us answer questions we have and provide relevant information for park management.

The park staff would be happy to work with you to obtain the necessary research permits for any project on National Park Service lands. In addition, we could provide logistic support such as float or wheel plane transportation as availability permits. This could even include a back-haul from a Park Service mission.

As you are aware, we have recently hired Diane Sanzone as our Arctic Network Coordinator. The Arctic Network includes the Western Arctic Parklands (4 parks) and Gates of the Arctic National Park and Preserve. The vastness of this network (over 21 million acres) will require collaboration with researchers from many affiliations. Your project could tie-in very nicely with some of our long-term monitoring efforts.

My staff has been very pleased with your timely and professional communication, and completion of applications for previous research, as well as your willingness to share those results.

Good luck Martin on your funding pursuits. If you have any further questions or need any clarification, please call Tom Liebscher at 907-455-0620. We look forward to working with you.

Sincerely,

David Mills
Superintendent

Prof. Dr. Uta Steinhardt
University of Applied Sciences
Faculty Landscape Management and Nature Conservation
Friedrich - Ebert - Strasse 28
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Fachhochschule Eberswalde

Eberswalde, 2004-01-13

To: Whom it may concern

Subject: Student help for NOAA Postdoctoral Project, Wilmking

This is to certify that we are willing and able to provide student help for two summer field seasons and laboratory for the project: "Land-cover change as the driver for carbon budgets at northern treeline in Alaska - From isotopic signature in trees and soils to local and regional feedbacks to the global climate system".

We have been working with Dr. Martin Wilmking over the last four years and sent two students to help in his Ph.D. research. We would like to continue this cooperation, because it provides our students with outstanding opportunity to gain experience in the field and lab. This cooperation has been supported by the German Academic Exchange Service in the past (travel costs) and we are confident that we will be able to secure funding for 2-4 more students in the next 2 years. Dr. Wilmking has been of great help in mentoring these students, in fact, the announcements have been so popular that we have been unable to send every student who wanted to go.

If you have any additional questions, please feel free to contact me

Sincerely yours

Uta Steinhardt

Prof. Dr. Uta Steinhardt

SCHOOL OF NATURAL RESOURCES & AGRICULTURAL SCIENCES
AGRICULTURAL & FORESTRY EXPERIMENT STATION UNIVERSITY OF ALASKA FAIRBANKS

January 13, 2004

From: Glenn Patrick Juday, Professor of Forest Ecology
Forest Science Department
University of Alaska Fairbanks
Fairbanks, AK 99775, U.S.A.
Tel: 1 (907) 474 6717
email: g.juday@uaf.edu

Dear Martin,

Thank you for stopping by and meeting with Valerie Barber and myself to describe your new project and funding pursuits. The proposal to the 2004 NOAA Postdoctoral Program in Climate and Global Change entitled “Land-cover change as the driver for carbon budgets at northern treeline in Alaska – From isotopic signature in trees and soils to local and regional feedbacks to the global climate system”, addresses many questions of high interest to us. We are currently investigating the impacts of Climate Warming on Interior Alaska's forest tree species (DOE, NIGEC/WESTGEC: “Response of Pacific Northwest and Alaskan Forests to Recent Multiple Environmental Changes”).

It would be of great help to us to compare results you will obtain from your work at treeline with our results from the Interior of Alaska. Your novel approach of scaling plot level measurements to the region using forest cover classes is of great importance. We would like to offer the following cooperation and contribution:

We will sponsor one student per year to come from Germany to work with you ($3000/yr). That student will collect additional samples from your field sites, which will be used in our comparison study. Also we plan to purchase IKONOS imagery and will contribute up to $5600 for additional imagery to test your scaling-up approach at treeline.

I wish you luck in your funding pursuits and hope to continue our collaboration.

Sincerely,

Glenn Patrick Juday